

# **Effectiveness of FRP in Reducing Corrosion in a Marine Environment**

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**2009 US Army Corrosion Summit  
Clearwater, FL**

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# Pile Corrosion



# Pile Corrosion



Courtesy - Alltrista





# Outline



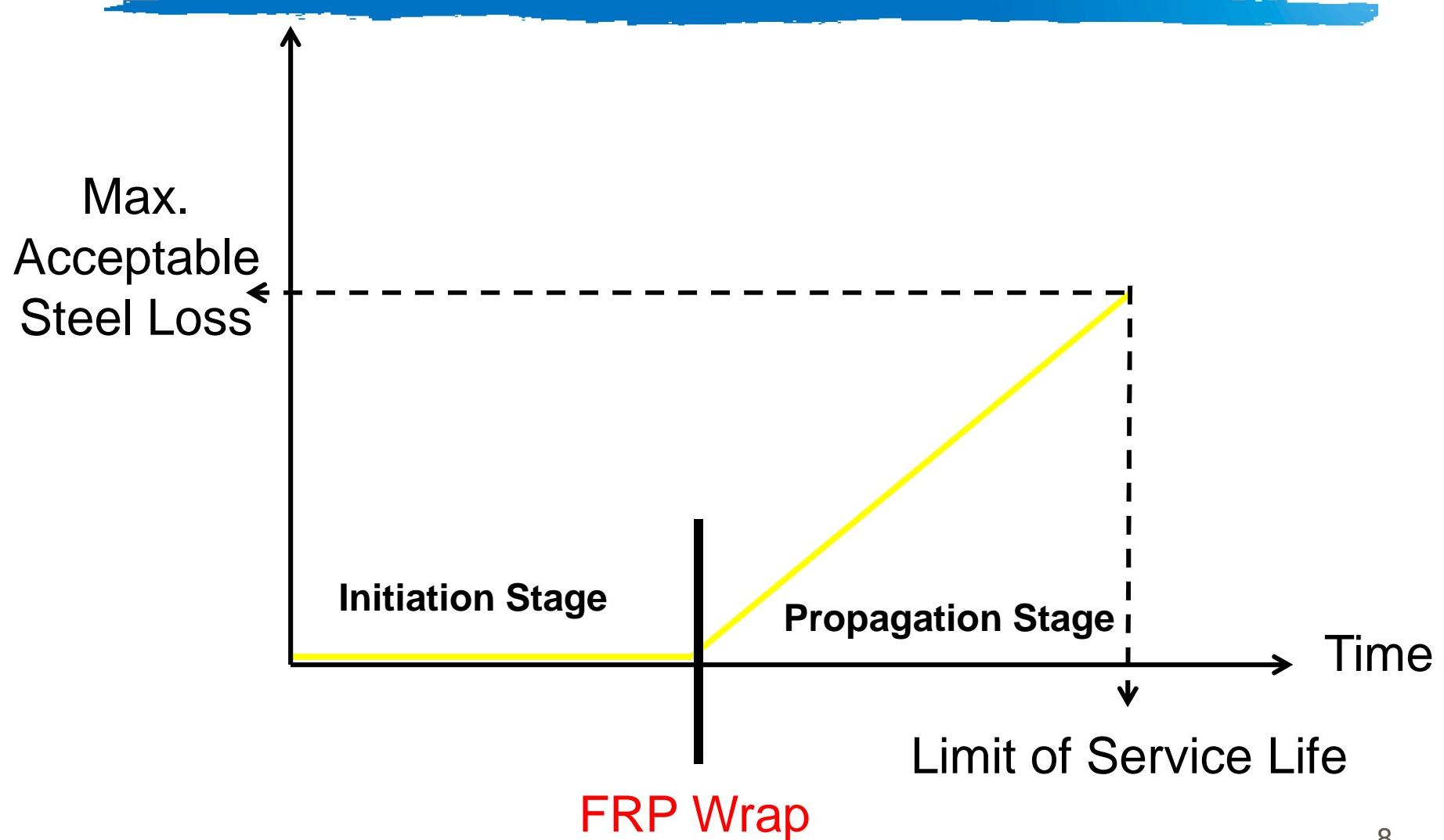
- Background
- Test Program
- Findings
- Field Applications
- Concluding Remarks
- Acknowledgements

# **Project Goals**

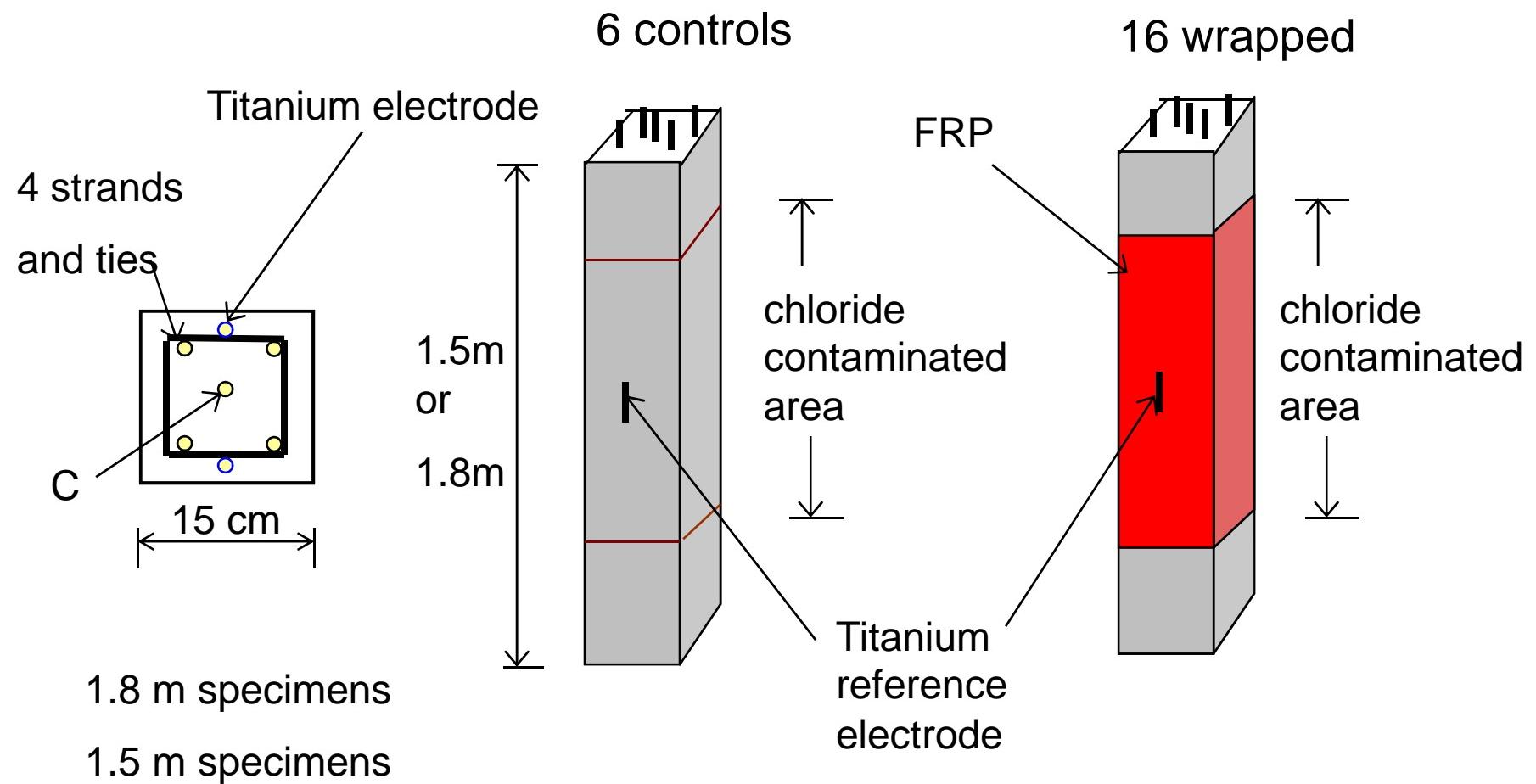
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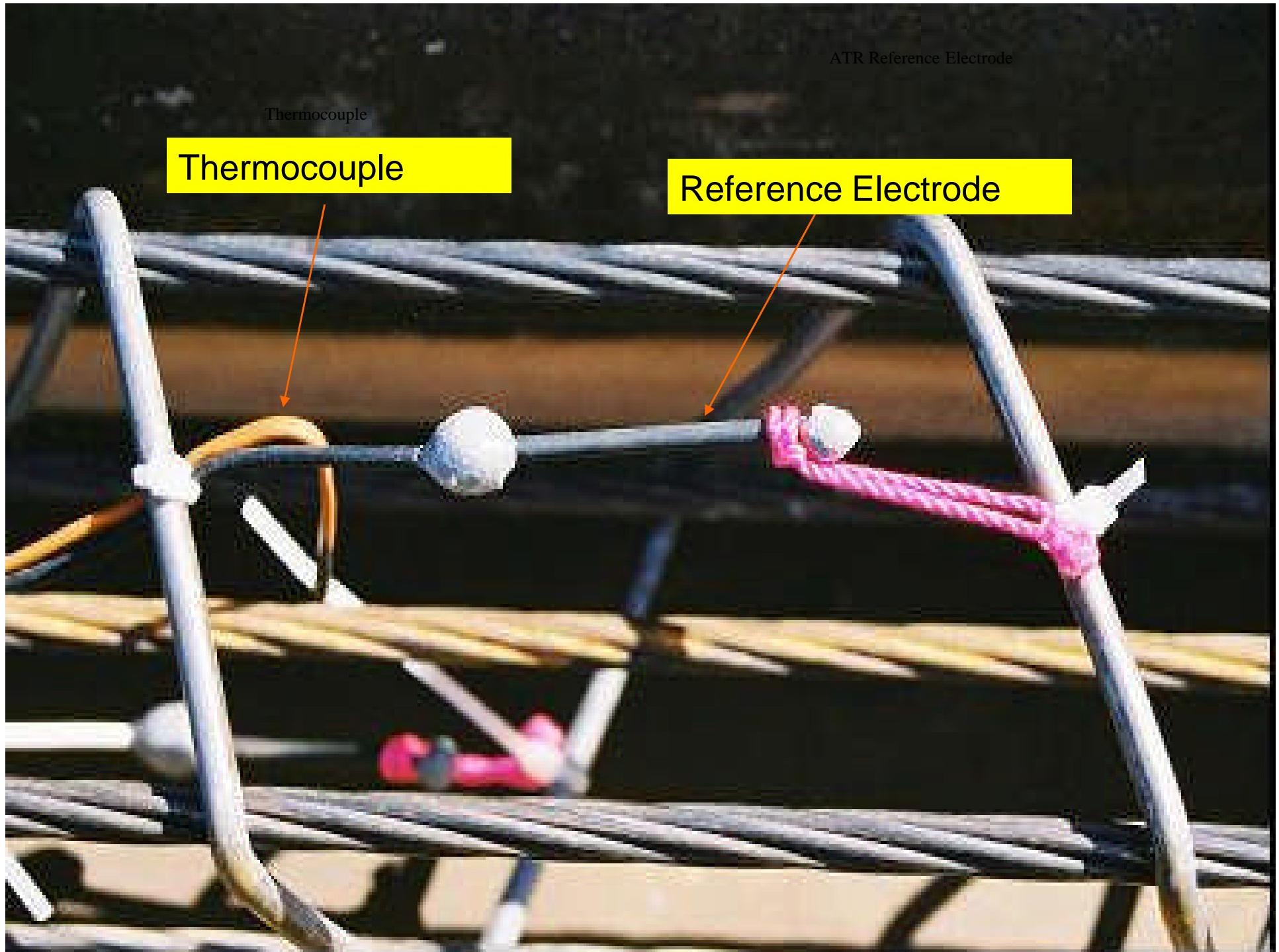
- How effective is FRP in mitigating corrosion?
- How important is the pre-wrap repair?  
*(Not covered)*
- How feasible is it to conduct field repairs?

# Tuutti's Corrosion Model



# Test Specimen







Concrete + chlorides

# **FRP Wrapping**



- 28 days
- Glass
  - 1, 2, 3, 4 layers
- Carbon
  - 1, 2, 3, 4 layers

# Carbon Fiber Wrap



# Glass Fiber Wrap



# Ambient Exposure



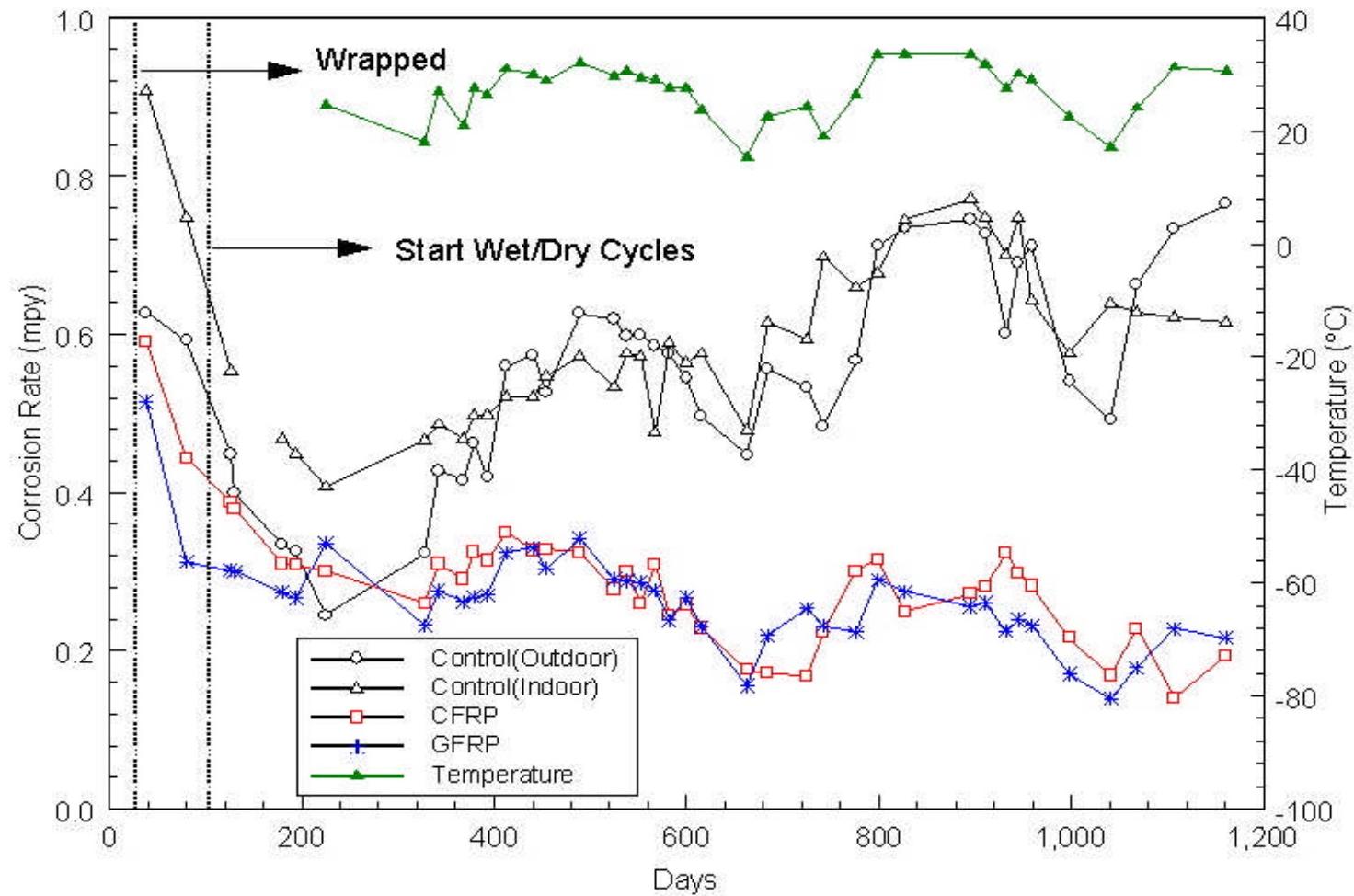
- 3.5% salt water
- Wet/dry cycles: every 6 hrs
- 1160 days (3 yrs 2 months)



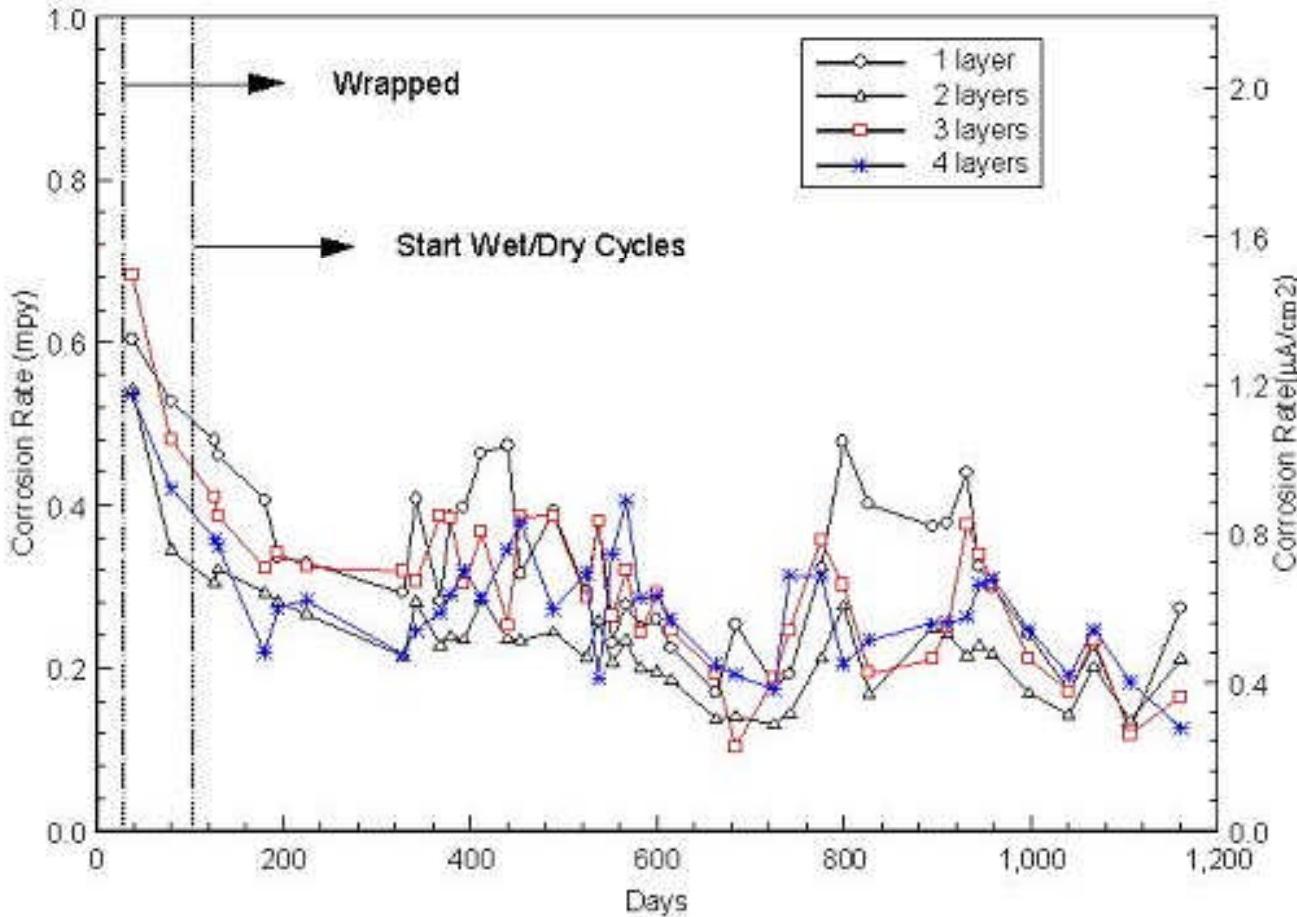
# Controls vs Wrapped Specimens



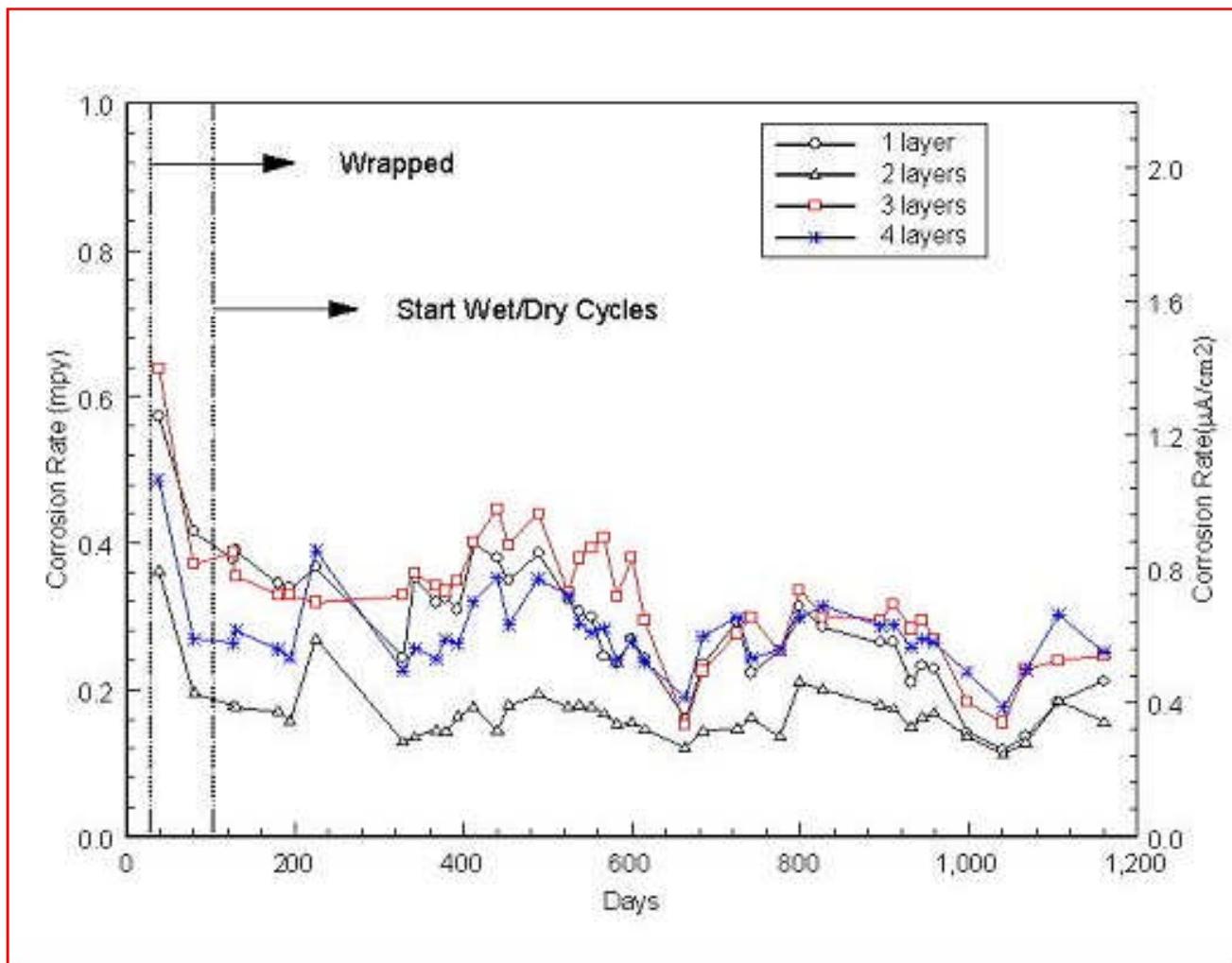
# Effect on Corrosion Rate



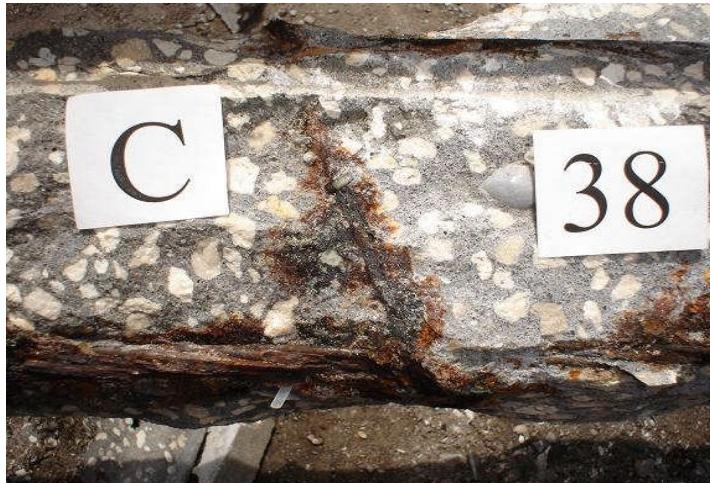
# Role of Layers - CFRP



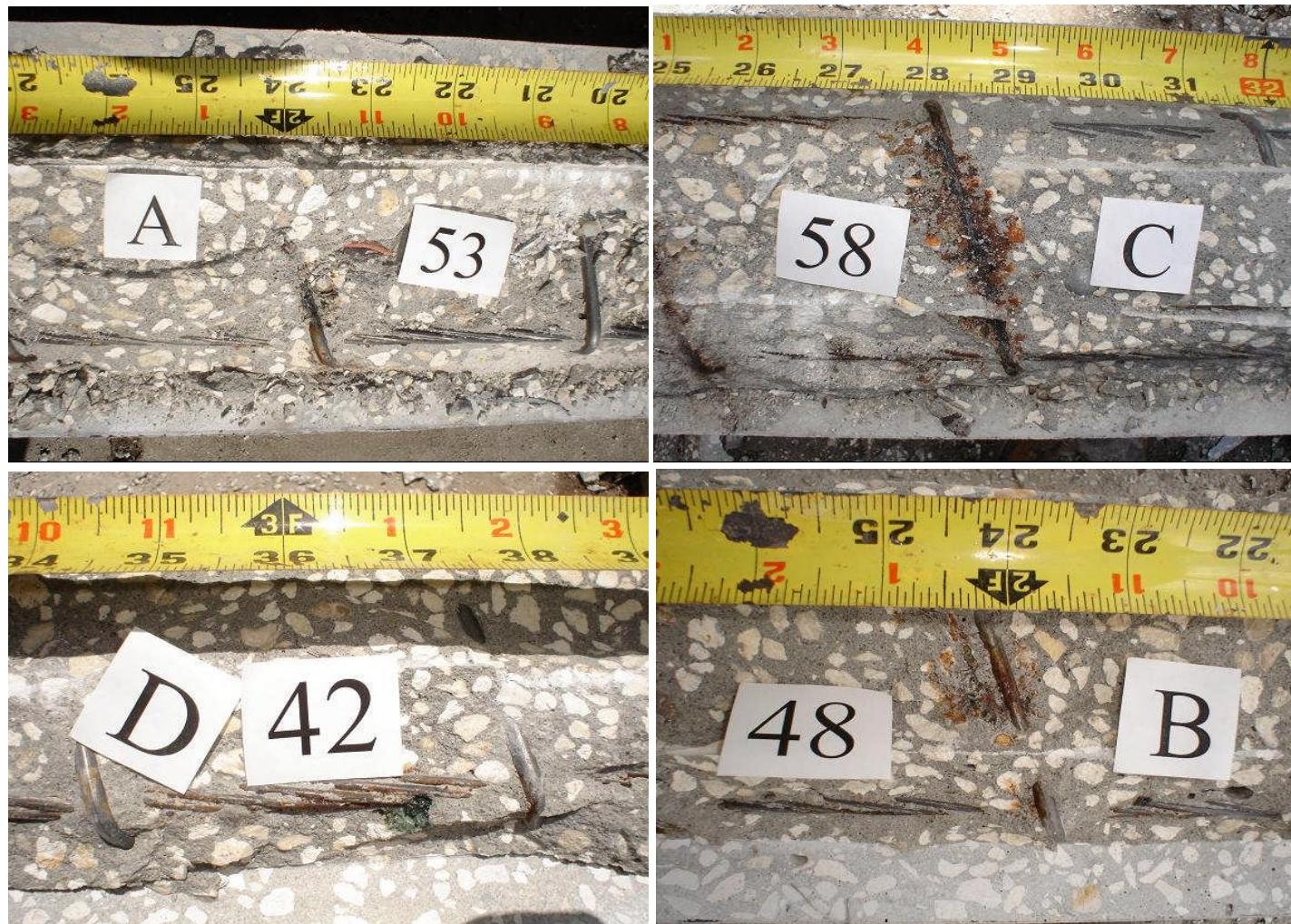
# Role of Layers - GFRP



# Unwrapped Controls



# Wrapped Specimens



# Retrieved Strands



Outdoor Control

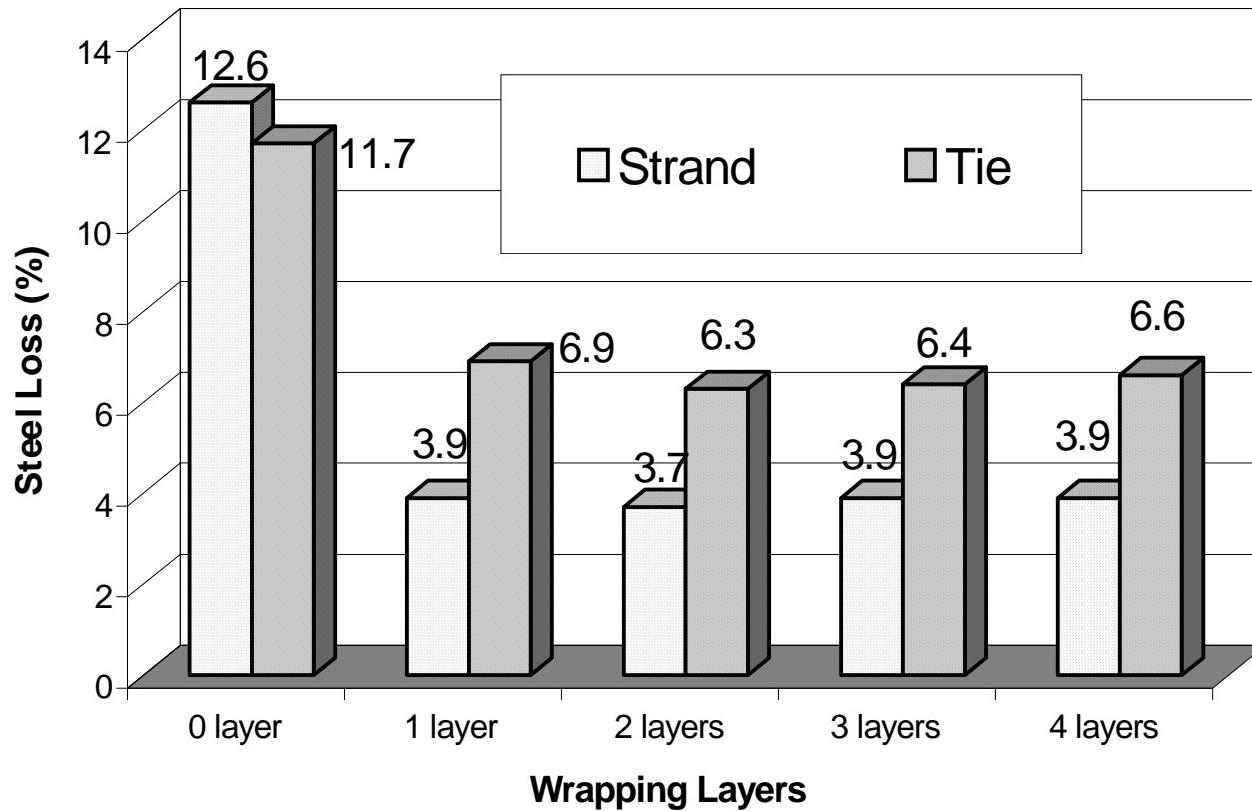
30 wire  
breaks in  
6 controls



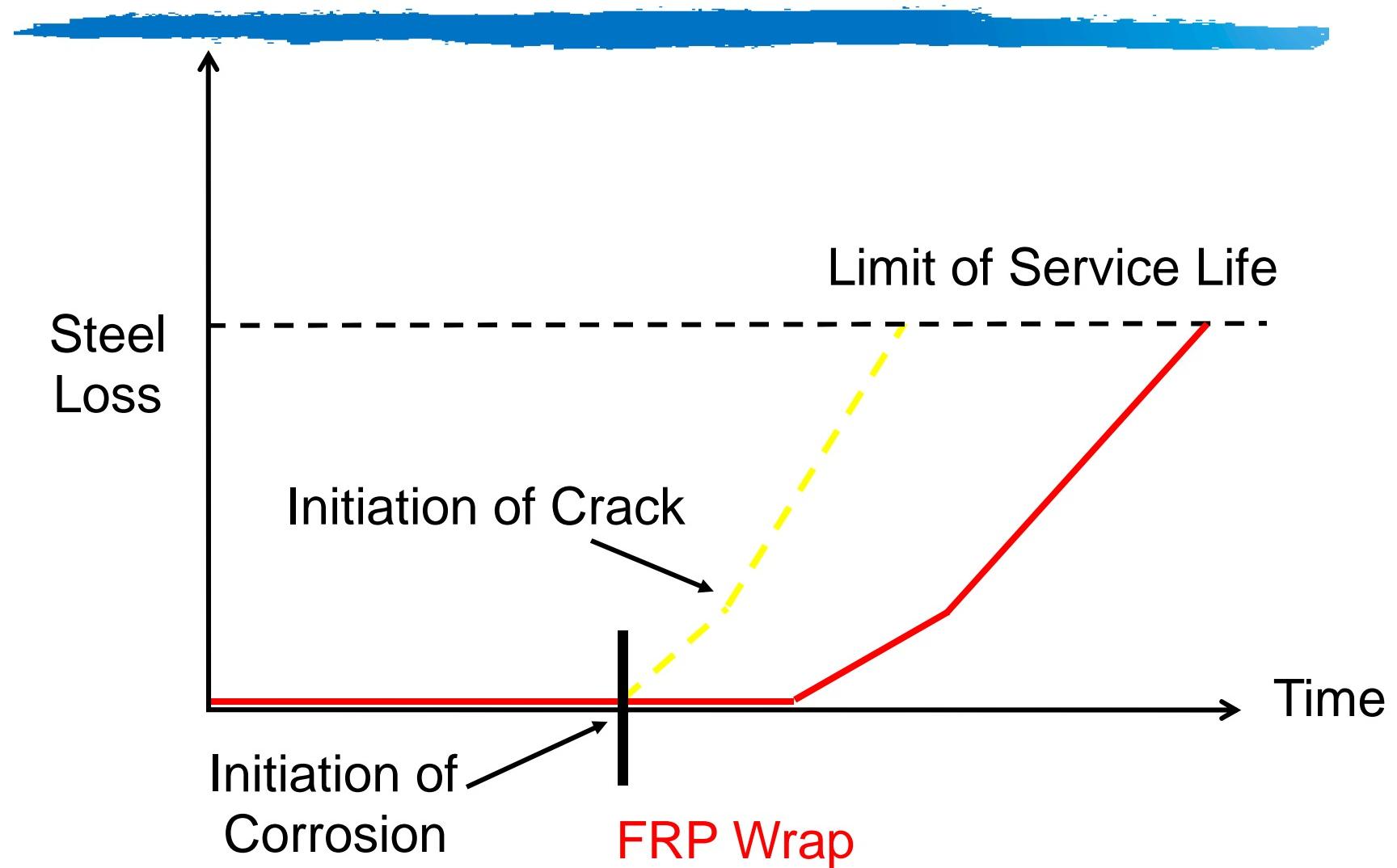
CFRP Wrapped

1 wire  
break in  
16 FRP  
specimen

# 1/3<sup>rd</sup> Metal Loss in Wrapped Specimens



# Implications



# **Why?**

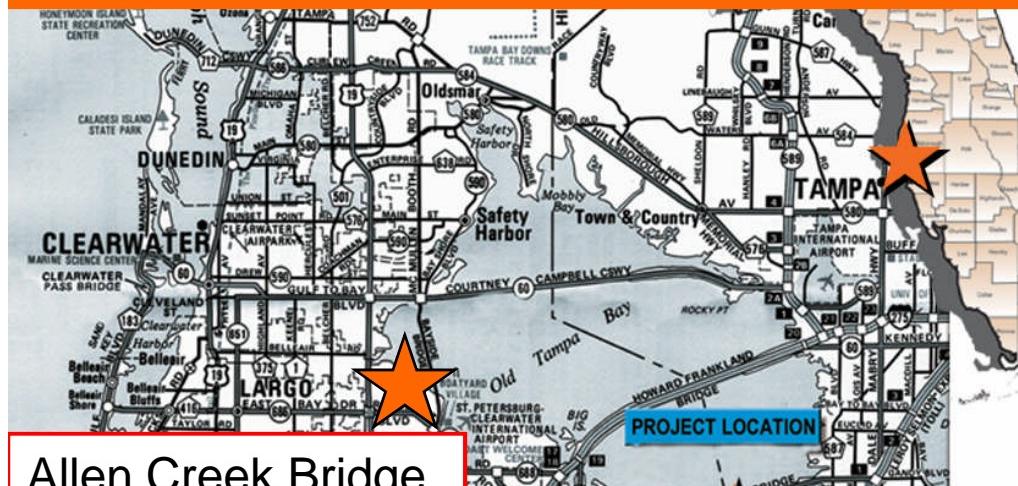


- Tests are underway to evaluate FRP's performance as a barrier
- If possible, we would like to evaluate coatings that could conceivably be used to improve FRP's performance



# Field Validation

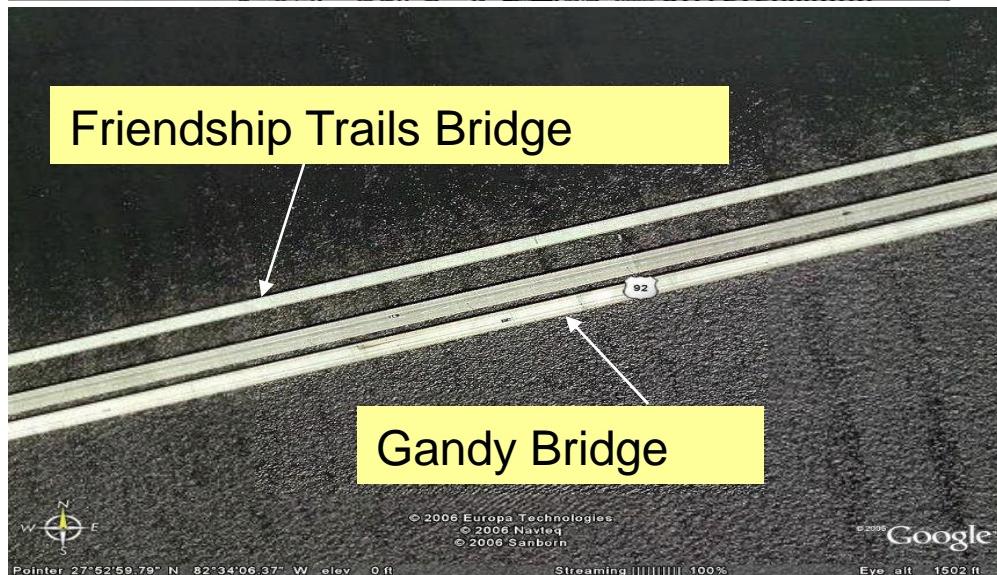
# Field Demonstration Studies



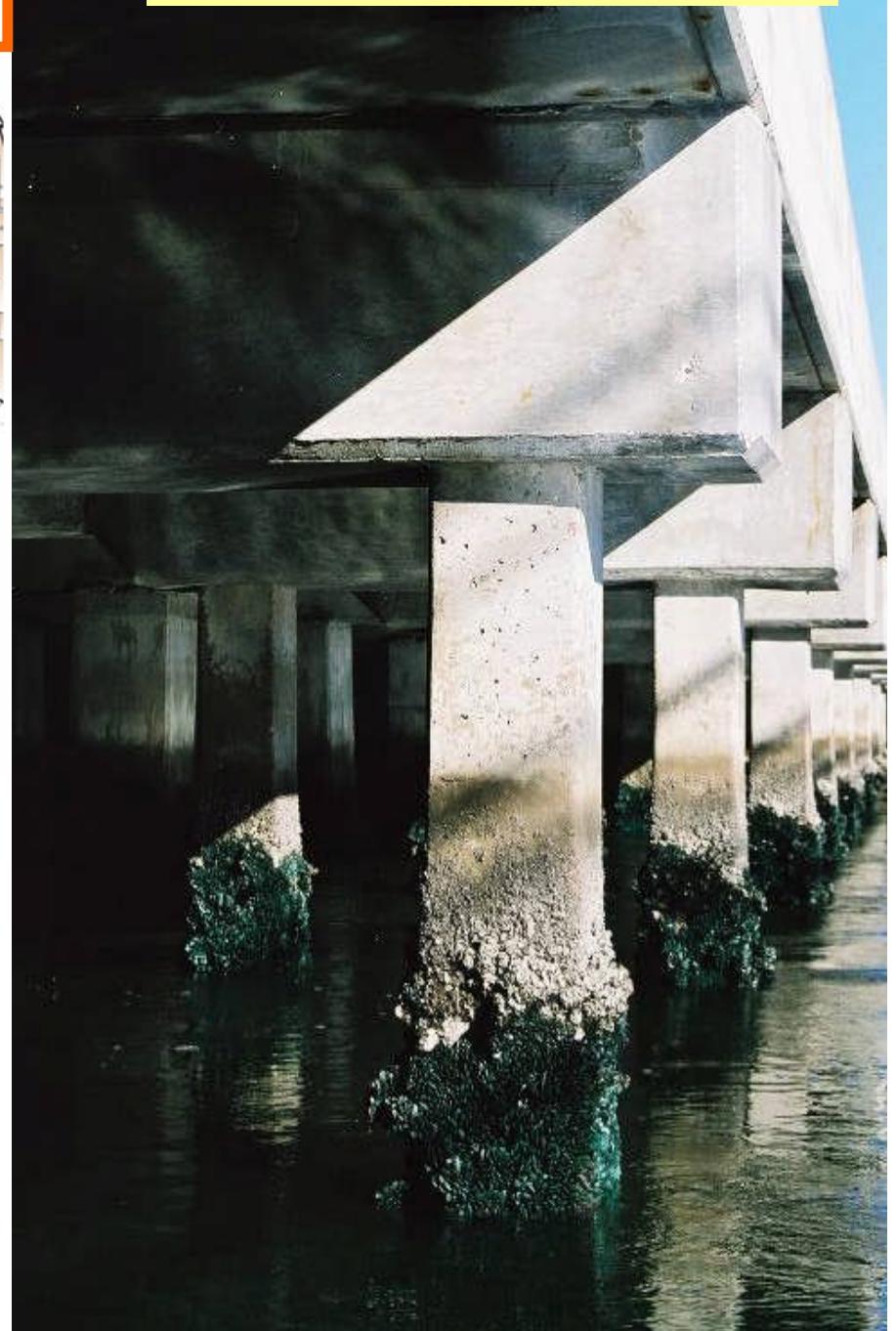
Allen Creek Bridge



Gandy Bridges



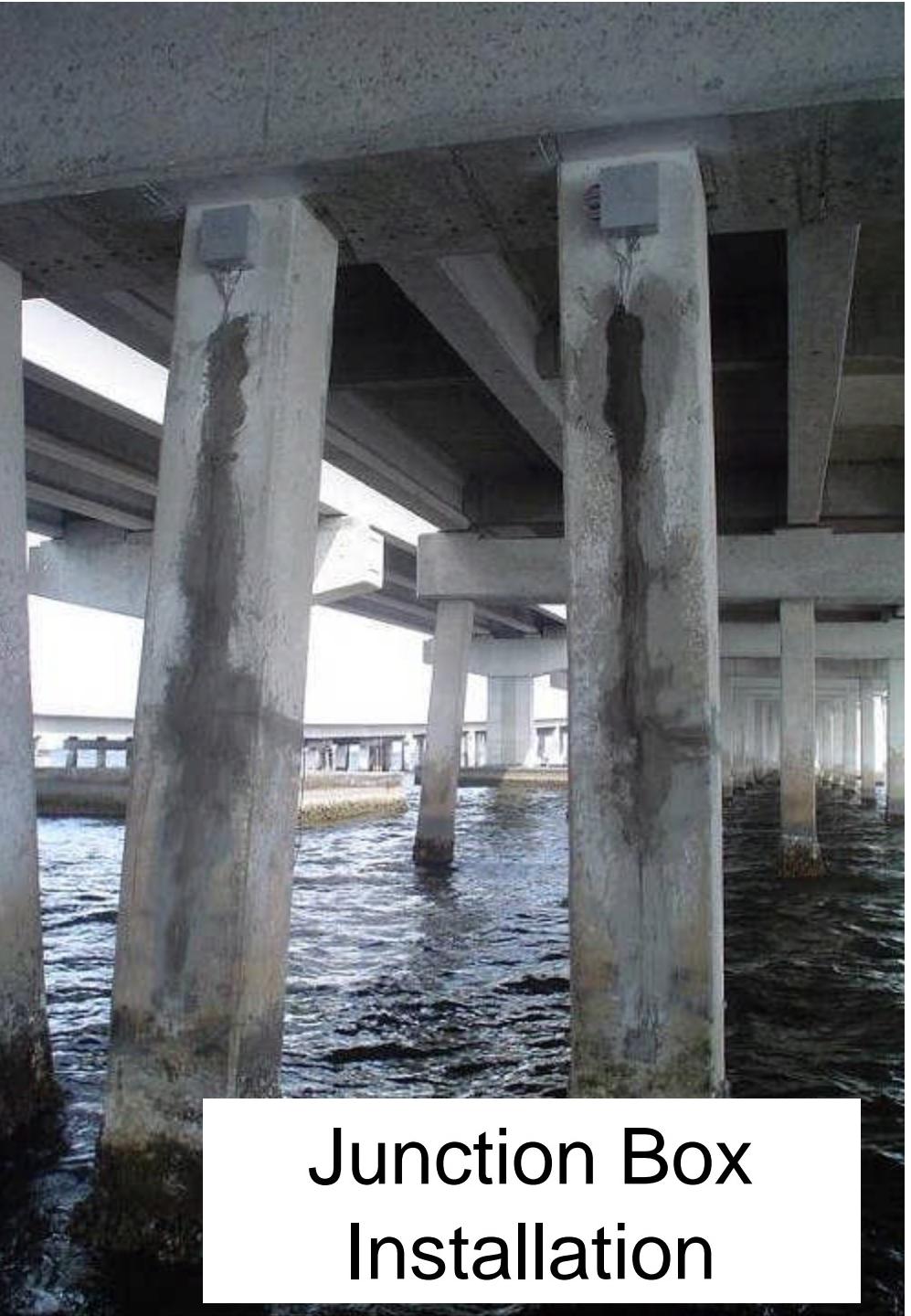
Allen Creek Bridge, Clearwater



# Gandy Bridge, Tampa



Linear  
Polarization



Junction Box  
Installation

## Measured Corrosion Rates in Controls vs Wrapped Piles

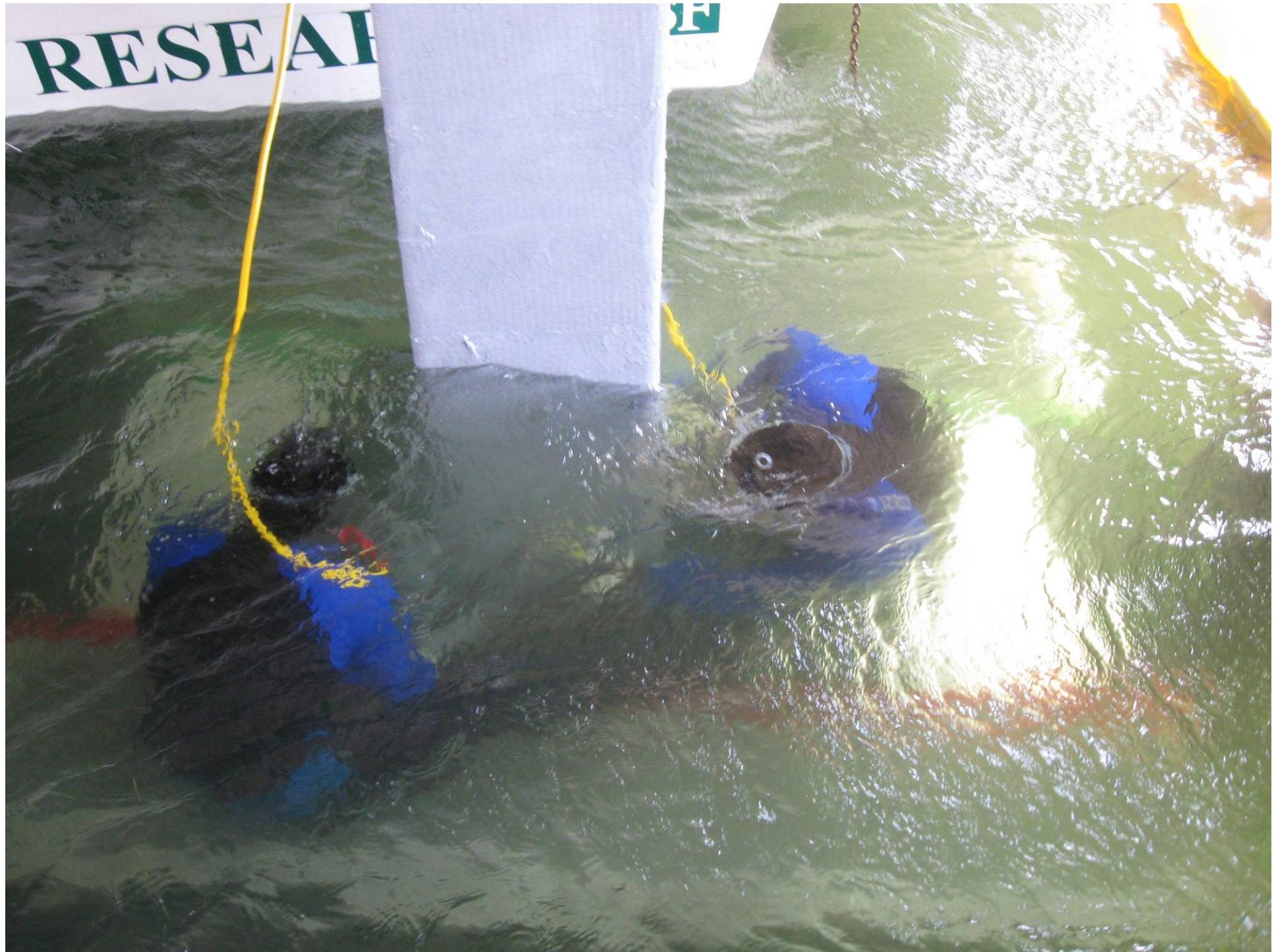
Pile	Date	Rate ( $\mu\text{m}/\text{yr}$ )
Control 91 cm above HWL	Nov 2004	8.39
	Jun 2005	6.77
	Aug 2007	9.46
Control 31 cm Below HWL	Nov 2004	49.6
	Jun 2005	20.48
	Aug 2007	38.48
Wrapped Pile 91 cm above HWL	Nov 2004	18.52
	Jun 2005	7.34
	July 2007	5.75
Wrapped Pile 31 cm Below HWL	Nov 2004	194.09
	Jun 2005	38.82
	July 2007	10.19

# Latest Application

Grove Isle Bridge, Miami  
January 2009







# CP + Wrap + Pressure Bag



NCHRP-IDEA-128

## Concluding Remarks

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- ➊ FRP slows down the corrosion rate
- ➋ Performance of CFRP and GFRP are comparable
- ➌ Performance appears to be independent of number of layers
- ➍ Linear polarization correctly predicts trends

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